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Keynes' Business Cycle: Animal Spirits and Crisis

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Introduction

Today, we are reeling from the effects of the worst economic crisis since the Great Depression. Job losses and bankruptcies have had a devastating impact on those in the developed world and time will only tell what the final cost will be to the globe's poorest citizens (Baily and Elliott, 2009 and International Monetary Fund, 2009). Recovery, particularly of employment, has been slow and policymakers and citizens throughout the globe have turned to economists for answers.

The predominant view in the mainstream school of thought has been that while we could not possibly have predicted the collapse (Bezemer, 2009), it is evident in hindsight that the culprit was inappropriate monetary policy (particularly low interest rates) which encouraged high levels of debt and overinvestment (Taylor, 2009). It was, therefore, exogenous factors that upset the balance of the economy and brought on crisis and collapse. Unusual and unique events conspired with poor policy choices and bad timing to create a perfect storm of financial disaster.

Not all economists agree with this diagnosis, however. Those in the Post Keynesian school, for example, not only raised voices of concern well before the crisis struck, but they have argued consistently that the problems we face are systemic.[1] Capitalism is prone to regular and sometimes catastrophic collapse because of the specific structure of the feedback loops and delays in the system and as a consequence of the psychology and sociology of the human beings whose behavior we are modeling. If this is not consciously recognized, they contend, then appropriate responses will be not be designed and economic crises will remain a permanent and significant feature of our world.

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[1]For evidence of the pre-crash predictions, see Baker 2002, Godley 2000, Godley and Wray 2000, Godley and Zezza 2006, Tymoigne 2007, and Wray 2000, 2001, 2006, and 2007. See also the Levy Institute web page (www.levy.org).

The purpose of this paper is to build a model that illustrates the key structural factors that Post Keynesians claim create this cycle. It does so by relying primarily on chapter twenty-two of John Maynard Keynes' 1936 publication, *The General Theory of Employment, Interest, and Money* (hereafter *General Theory*; Keynes, 1964).[2] It will be shown that, because of the manner in which people form expectations, every expansion sows the seeds of recession and that, while the build up during the upswing is slow and steady, the collapse is sudden and steep. The heart of the problem is the fact that economic agents inevitably become overly optimistic as the economy grows, only to be disappointed when otherwise-reasonable profits fall short of their inflated forecasts. The cycle of crisis not only contributes to recession and unemployment, it also keeps the total stock of physical capital from rising to the level that would actually satisfy current demand. This view relies on the existence of feedback, delays, and asymmetries to explain endogenous instability and is thus well-suited to system dynamics modeling. Though recent events were more complex, even this simple, seventy-four year old model does a much better job of explaining the underlying causes of the current crisis than do more popular approaches.

The paper will proceed as follows. In the next section, the Post Keynesian theory of the business cycle, as based on Keynes' chapter twenty-two, will be explained. Following that, the system dynamics model will be built and validated. Various manipulations of the model will be undertaken so that the key structures determining model behavior can be determined. The paper concludes by comparing the policy choices available to us.

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[2]See Keller and Carlson (1982) for an excellent discussion of this overlooked chapter.

Keynes' Theory of the Business Cycle

Post Keynesian economics draws its inspiration from the work of John Maynard Keynes.[3] Writing during the Great Depression, Keynes argued that free-market economies were crisis-prone and that, absent substantial reforms, we would find ourselves facing increasingly stagnant conditions. While the post-war growth of the public sector has served as something of a buffer against the instability of which he warned, this has occurred more by chance than by design. Because of this, we remain vulnerable to the very same forces that came into play in 1929.

Keynes argued that the economy's core problem was the inability to generate sufficient physical investment spending to maintain full employment. To understand this, assume first that there is no government or foreign trade sector. Keynes does this in the *General Theory* not just to simplify the analysis, but also to show that a completely closed economy driven solely by private-market forces can generate cycles and crises–neither government policy errors nor imported foreign instability are necessary. The remaining firms and their workers can be divided into two sectors:

- consumption goods and services (C): the industry producing those goods and services of which households are the end user;
- investment goods and services (I): the industry producing those goods and services used by firms in the production of their products, but which do not become part of their

[3]Note that the economics of Keynes and what is known as "Keynesian" economics are not the same thing. The latter is a very diluted version of Keynes' work and though it contains some of his vocabulary, very little of the unique elements of his analysis remain. That does not make Keynesian economics wrong, of course, just inconsistent with what Keynes said. It is the belief of Post Keynesian economists, however, that Keynesianism is **both** not what Keynes said and wrong.

products.[4]

These two added together yield the total sales of all goods and services produced and sold in a given year, or Gross Domestic Product (GDP):

(1) $GDP = C + I$

As GDP rises, employment will rise. If we assume that there is some level of GDP sufficient to generate full employment (say GDP*) and if we further assume that we are currently in a situation where GDP < GDP*, then reaching GDP* will require an increase in either or both C and I. Herein lies one of the problems, says Keynes. Bear in mind that if GDP represents the total sales of all goods and services produced and sold in a given year, then it must also be the total income generated in the macroeconomy. But, the behavior of individuals is such that we will witness "a greater proportion of income being saved as real income increases" (Keynes, 1964, p.97). At first, rising incomes are happily spent as old cars are replaced, big-screen TVs are purchased, home appliances are upgraded, et cetera. However, as these consumer durable purchases will not likely be repeated for some time, so that as GDP continues to rise over the business cycle the ratio of C/GDP tends to fall with households shifting their attention toward saving. Hence, the role of physical investment in reaching GDP* is key–*if it cannot rise at an increasing rate so as to offset the decline in C/GDP, then full employment cannot be achieved.* Unfortunately, says, Keynes, we are unlikely to be able to maintain a constant level of I, let alone an increasing one.

Physical investment spending is primarily a function of two variables: the rate of interest

[4]Note that this specifically excludes raw materials (that which becomes part of their products), the cost of which is already included in the prices firms charge for the goods and services they sell. This is standard practice.

(r) and the marginal efficiency of capital (mec). As the former rises, it tends to lower investment because it raises the cost of financing projects. With respect to the latter, Keynes defines the marginal efficiency of capital as, "that rate of discount which would make the present value of the series of annuities given by the returns expected from the capital-asset during its life just equal to its supply price" (Keynes, 1964, p.135). It is, roughly speaking, the present value of the expected profit stream from the best available investment project expressed as a rate, which makes it directly comparable to the rate of interest at which the firm must borrow. If mec > r, then the firm will undertake the project in question; if mec < r, then it will not. As firms invest, the mec falls because a) they will undertake the projects they forecast to be the most profitable first, leaving less profitable ones for later, and b) as physical capital becomes less scarce, the prospect of profiting by adding to it diminishes.[5] Firms can be expected to continue investing until they have driven mec to the level of r (or not invest until mec rises to the level of r).

Keynes writes that for each type of physical capital, a schedule of the mec can be drawn such that it shows how much investment must take place to move the mec to a particular level. This is illustrated in Figure 1. On schedule MEC, it shows that in order for mec to equal mec_0, a level of investment I_0 is required. Now imagine that we are still at I_0 but that the rate of interest falls until it is at the same level as mec_1 (note that, since they are measured in the same units, the vertical axis can be used to show both the mec and the rate of interest). In that case, mec > r at I_0, causing investment to rise until mec = r at I_1. If expectations become more optimistic, then MEC shifts to the right, as shown with MEC'.

[5]Take, for example, restaurants as an example of physical investment. The more restaurants already in existence, the less likely building a new one will be profitable.

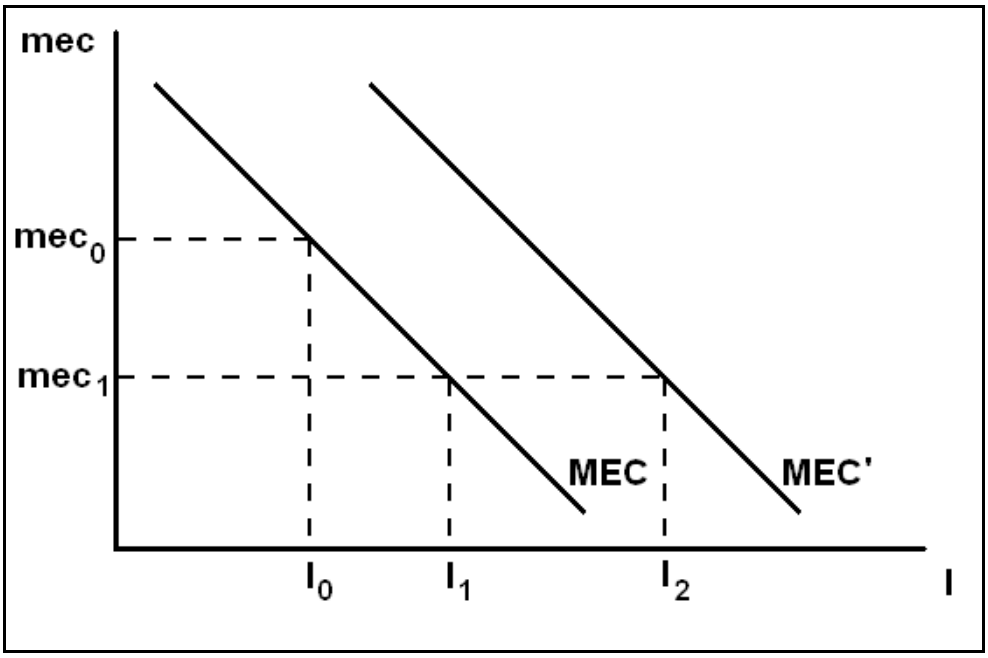

Figure 1: Schedule of the marginal efficiency of capital.

If the level of investment is the key to achieving GDP*, then the behaviors of r and mec are of great interest. Keynes made it clear, though, that he thought the former was much less important than the latter:

> Now, we have been accustomed in explaining the "crisis" to lay stress on the rising tendency of the rate of interest under the influence of the increased demand for money both for trade and speculative purposes. At times this factor may certainly play an aggravating and, occasionally perhaps, an initiating part. But I suggest that a more typical, and often the predominant, explanation of the crisis is, not primarily a rise in the rate of interest, but a sudden collapse in the marginal efficiency of capital (Keynes, 1964, p.315).

With respect to the latter, Keynes writes that it "depends, not only on the existing abundance or scarcity of capital-goods and the current cost of production of capital-goods, but also on current

expectations as to the future yield of capital-goods" (Keynes, 1964, p.315). All three of these were implicit in the derivation and discussion of the MEC schedule in Figure 1, but for clarity Figure 2 offers a summary. There, investment is shown to be a function of the interest rate and the mec, with mec determined by the existing stock of physical capital (or K, which takes into account "the existing abundance or scarcity of capital-goods" from the above quote), the current price of producing physical capital equipment (or cost of K, which represents "the current cost of production of capital-goods"), and current expectations of the future yield of capital (or speculative profit expectations, which represents "current expectations as to the future yield of capital-goods"). The reason for the negative effect of rising costs of capital should be obvious and it has already been explained that a rising stock of capital has a depressing effect on the mec because a) firms will undertake the most profitable projects first and b) adding a new factory is less likely to be profitable when many such factories already exist. What has not been discussed to this point are speculative profit expectations. This involves the interplay of a number of concepts unique to Keynes' analysis.[6]

[6]Concepts that are, incidentally, almost completely absent from what became known as "Keynesian" economics.

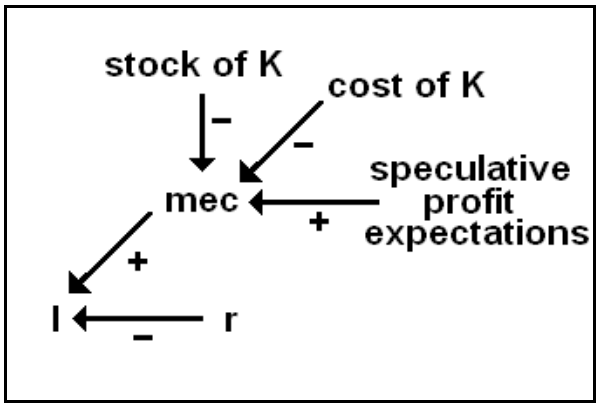

Figure 2: Determinants of investment.

Keynes was very interested in the psychology of the investment decision. His master's thesis, *A Treatise on Probability*, dealt with decision making and rejected the idea that choice can be reduced to expected values or other mathematically-precise concepts (Keynes, 1921). In the *General Theory*, he writes that

> ...human decisions affecting the future, whether personal or political or economic, cannot depend on strict mathematical expectation, *since the basis for making such calculations does not exist*. (emphasis added; Keynes, 1964, pp.162-3).

This is so because the future is uncertain:

> By 'uncertain' knowledge, let me explain, I do not mean merely to distinguish what is known for certain from what is only probable. The game of roulette is not subject, in this sense, to uncertainty; nor is the prospect of a Victory bond being drawn. Or, again, the expectation of life is only slightly uncertain. Even the weather is only moderately uncertain. The sense in which I am using the term is that in which the prospect of an European war is uncertain, or the price of copper and the rate of interest twenty years hence, or the obsolescence of a new

> invention, or the position of private wealth-owners in the social system in 1970. About these matters *there is no scientific basis on which to form any calculable probability whatever*. We simply do not know (emphasis added; Keynes, 1937, pp.213-4).

Because capital lasts for many years, investment is necessarily very forward-looking and therefore fraught with Keynes-style uncertainty. If Keynes' contention that we are largely ignorant of the things we need to know to make a reasonable evaluation is correct, it seems incredible that anyone would accept the financial risks associated with building a new factory, restaurant, or assembly line. Indeed, a coldly rational and calculating person would not. But, Keynes also believed that human beings exhibit a spontaneous optimism, or an urge to action rather than inaction, that he called "animal spirts:"

> ..it is our innate urge to activity which makes the wheels go round, our rational selves choosing between the alternatives as best we are able, calculating where we can, but often falling back for our motive on whim or sentiment or chance (Keynes, 1964, p.163).

Human beings are thus complex creatures, with a rational and emotional side. Both of these are necessary if investment is to take place. The former is essential to the processing of the information that we do have; the latter compensates for the fact that we inevitably do not have very much.

The "speculative profit expectations" of Figure 2 represents more than just reason combined with animal spirits, however; Keynes also believes it important to include a specification of the object of agents' expectations and the time horizon they employ. This, he

argues, is derived from the stock market. Such an approach is unusual because the mainstream generally draws a clear line between the financial and real sectors of the economy, with the former playing what amounts to a supporting role. This is especially true of the stock market where the overwhelming majority of activity involves secondary sales and has no direct impact on the issuing firm. But, Keynes argues that:

> ...the daily revaluations of the Stock Exchange, though they are primarily made to facilitate transfers of old investments between one individual and another, inevitably exert a decisive influence on the rate of current investment. For there is no sense in building up a new enterprise at a cost greater than that at which a similar existing enterprise can be purchased...(Keynes, 1964, p.151).

He therefore believes that stock market valuations of financial investments should be taken seriously and ought to be viewed as affecting (and perhaps reflecting) the opinions of those involved in physical investment.

But, the nature of financial markets makes this an unwelcome connection. Physical investment requires a long-term time horizon. Months may pass between the decision to undertake a project and the breaking of ground. Many more months may elapse before the new investment is actually ready to come on line as capital, and then months again before the first revenues are earned. The capital may remain on line for years or even decades. In addition, the opportunities to change directions once the investment has begun are few, far between, and expensive. Physical investment is therefore done best when it is preceded by careful and meticulous planning by individuals who are committed to the project even when circumstances change.

In financial markets, however, an investor can sell an asset within minutes of acquiring it. This means that there is no need for in-depth, or even much beyond cursory, research into the issuer's plans, personnel, history, competition, et cetera. If the price falls unexpectedly, it is easy enough to sell the asset at a slight loss and move on to greener pastures. Nor is it evident that those making more careful appraisals are at an advantage when the short-term speculators are driving the market. This inevitably gives those involved in financial investment a very short time horizon and it allows a large "proportion of the equity in the community's aggregate capital investment [to be] owned by persons who do not manage and have no special knowledge of the circumstances, either actual or prospective, of the business in question" (Keynes, 1964, p.153). The object of the game becomes forecasting the psychology of the market rather than evaluating the profitability of the asset issuer. As a consequence, "Day-to-day fluctuations in the profits of existing investments, which are obviously of an ephemeral and non-significant character, tend to have an altogether excessive, and even an absurd, influence on the [stock] market" (Keynes, 1964, pp.153-4). Furthermore, since the resulting pricing structure of financial assets will be "established as the outcome of the mass psychology of a large number of ignorant individuals," it will be "liable to change violently as the result of a sudden fluctuation of opinion due to factors which do not really make much difference to the prospective yield" (Keynes, 1964, p.154). Stock markets may therefore be subject to "waves of optimistic and pessimistic sentiment" (Keynes, 1964, p.154).

Those undertaking physical investment cannot help but be affected by the atmosphere this creates (indeed, they may also be participants in the financial market). And while Keynes cautions the reader that, "We should not conclude from this that everything depends on waves of

irrational psychology," it is nevertheless important to bear in mind that among the forces impacting on the mec in Figure 2 are the speculative forecasts of those participating in the financial market, people who may be ignorant of the circumstances affecting the issuer of the asset they hold and who (just as much as those investing in physical capital) must rely on animal spirits to overcome the uncertainty of the economic environment (Keynes, 1964, p.162). As Keynes famously said, "When the capital development of a country becomes a by-product of the activities of a casino, the job is likely to be ill-done" (Keynes, 1964, p.159).

This paints the mec as being driven by two relatively objective factors, the stock of capital and the cost of capital, and one highly subjective one, speculative profit expectations. The latter is a function of investors' rational selves, their animal spirits, and the influence of the short-term impulses of the stock market. In the system dynamics model developed below, the last will be shown to be the decisive element.

Though the mec is the primary source of instability and cycle in investment, Keynes nevertheless devoted four chapters of the *General Theory* to discussing interest rates. Indeed, he thought it vital to separate himself from earlier views and create a new monetary theory based on uncertainty:

> ...our desire to hold Money as a store of wealth is a barometer of the degree of our distrust of our own calculations and conventions concerning the future....The possession of actual money lulls our disquietude; and the premium which we require to make us part with money is the measure of the degree of our disquietude (Keynes, 1937, p.216).

Keynes saw interest rates not only as a reflection of the more traditional demands for financing,

but also as an indicator of our level of anxiety. The latter suggests a direct link between the mec and interest rates and further complicates the problems associated with generating levels of investment sufficient to move us to GDP*:

> ...the dismay and uncertainty as to the future which accompanies a collapse in the marginal efficiency of capital naturally precipitates a sharp increase in liquidity-preference — and hence a rise in the rate of interest (Keynes, 1964, p.316).

Thus, precisely when we might hope for a fall in interest rates to stave off a collapse in investment, we witness an increase. Changes in r may not precipitate crises, but nor to they act to alleviate them.

This is sufficient background to explain Keynes' theory of the business cycle. First, Figure 3 updates Figure 2 by including some of the new variables and linkages. Note that an increase in I will now raise both the stock of capital (after a lag) and the cost of producing new capital (more or less immediately) and that both of these create negative feedback loops. Also added are the determinants of the rate of interest, which include both the mec (as the inverse of people's disquietude about the future) and financing demand (assumed to be directly related to investment). This creates three more negative feedback loops with the capacity to limit growth: I to financing demand to r; I to K to mec to r; and I to cost of K to mec to r.

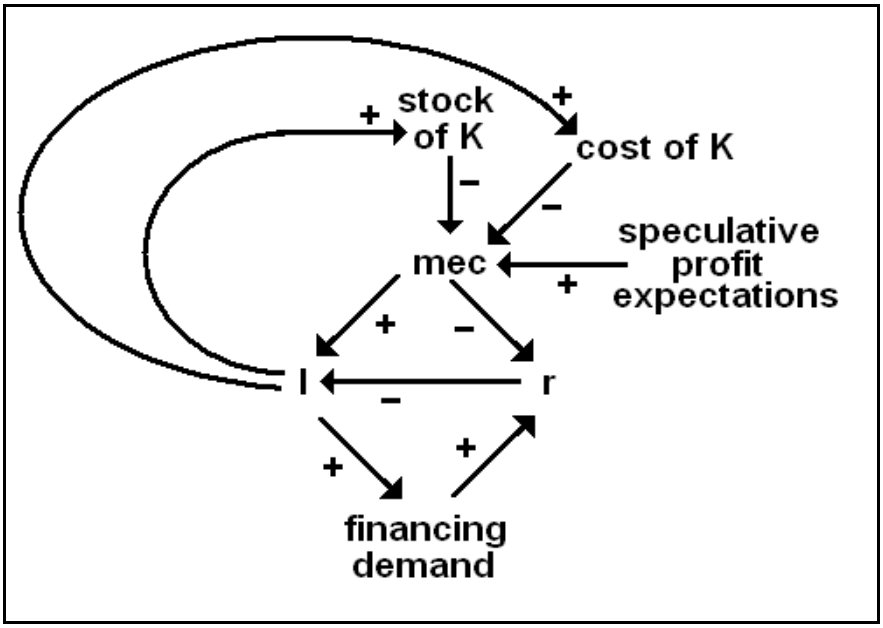

Figure 3: Determinants of mec and interest.

Despite these obstacles to raising investment, the real key to crisis and collapse is "speculative profit expectations." Though it will be specified in more detail in the system dynamics model, Figure 4 gives a basic sense of the relative importance of the various factors over the course of the business cycle. Assume we start off in expansion, with I rising and generating output and employment. It is simultaneously driving realized profits down, however, as K and cost of K rise. In addition, the increase in financing demand may place upward pressure on interest rates (although the generally high optimism could offset this, leaving r unchanged or at least as a minor factor). But the real action is in speculative profit expectations for, as the economy expands and the contrast with the earlier recession is fresh in people's minds, spontaneous optimism/animal spirits are encouraged (again, in a way not specified in Figure 4 but which will be outlined in the system dynamics model). Consecutive quarters of

high (if eventually falling) profits lead agents to believe that the consequences of any rise in K, cost of K, or financing demand are trivial compared to the returns promised by the booming economy:

> The later stages of the boom are characterised by optimistic expectations as to the future yield of capital-goods sufficiently strong to offset their growing abundance and their rising costs of production and, probably, a rise in the rate of interest also (Keynes, 1964, p.315).

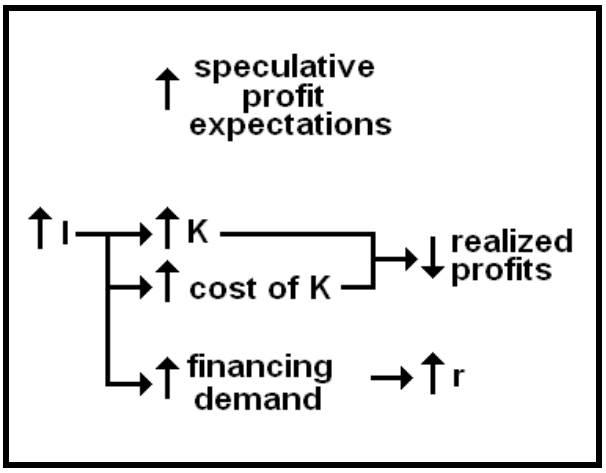

Figure 4: Economic expansion.

The gap between expectations and reality is growing and disappointment is inevitable. Given that those forming the expectations were operating just as much on emotion as reason and since the increasing influence and numbers of speculators among them may have had little real idea of the circumstances of the businesses whose shares they had purchased, the collapse can be very dramatic:

> It is of the nature of organised investment markets, under the influence of purchasers largely ignorant of what they are buying and of speculators who are

> more concerned with forecasting the next shift of market sentiment than with a reasonable estimate of the future yield of capital-assets, that, when disillusion falls upon an over-optimistic and over-bought market, it should fall with sudden and even catastrophic force (Keynes, 1964, pp.315-6).

Overreaction may occur in the sense that the earlier overly-optimistic view "is replaced by a contrary 'error of pessimism'" (Keynes, 1964, pp.321-2).

The greatest irony is the fact that the crisis occurs in a manner that prevents the market for capital from truly being saturated in the sense that the community has all it wants or needs. In the extended quote below, Keynes addresses this in language that brings to mind mainstream analyses of our current crisis (wherein the assumption is that low interest rates may have led to overinvestment):

> The preceding analysis may appear to be in conformity with the view of those who hold that over-investment is the characteristic of the boom, that the avoidance of this over-investment is the only possible remedy for the ensuing slump, and that, whilst for the reasons given above the slump cannot be prevented by a low rate of interest, nevertheless the boom can be avoided by a high rate of interest. There is, indeed, force in the argument that a high rate of interest is much more effective against a boom than a low rate of interest against a slump.
>
> To infer these conclusions from the above would, however, misinterpret my analysis; and would, according to my way of thinking, involve serious error. For the term over-investment is ambiguous. It may refer to investments which are destined to disappoint the expectations which prompted them or for which there is

> no use in conditions of severe unemployment, or it may indicate a state of affairs where every kind of capital-goods is so abundant that there is no new investment which is expected, even in conditions of full employment, to earn in the course of its life more than its replacement cost. It is only the latter state of affairs which is one of over-investment, strictly speaking, in the sense that any further investment would be a sheer waste of resources. Moreover, even if over-investment in this sense was a normal characteristic of the boom, the remedy would not lie in clapping on a high rate of interest which would probably deter some useful investments and might further diminish the propensity to consume, but in taking drastic steps, by redistributing incomes or otherwise, to stimulate the propensity to consume.
>
> According to my analysis, however, it is only in the former sense that the boom can be said to be characterised by over-investment. The situation, which I am indicating as typical, is not one in which capital is so abundant that the community as a whole has no reasonable use for any more, but where investment is being made in conditions which are unstable and cannot endure, because it is prompted by expectations which are destined to disappointment (Keynes, 1962, pp.320-1).[7]

Thus, in a world where technology, productivity, and resources are sufficient to generate an unheard-of standard of living in at least the developed world (and probably in the developing,

[7]Keynes does not deny that certain classes of investment may be overbuilt, only that this is not characteristic of the economy as a whole. He also agrees that inventory adjustment can cause "minor oscillations within the main movement of the Trade Cycle" (Keynes, 1964, p.322)

with certain institutional reforms), our economic system causes chronic unemployment, underinvestment, and cyclic and sometimes catastrophic breakdown. While the above descriptions are illuminating, without a formal model it is difficult to say where the key cycles and leverage points are, nor is it evident that Keynes' narrative provides an internally consistent explanation. This is addressed below.

System Dynamics Model

The system dynamics model shown in Figure 5 is adapted from Figure 3. The central variable is the marginal efficiency of capital, with the rest of the economy organized into five parts: gestation process, excess capacity in construction, scarcity of capital, speculative expectations, and liquidity preference. In terms of the base range of values in the system, whenever a guide was available from Keynes, this was followed. Otherwise, current economic data were consulted and extrapolations made. For purposes of this analysis, an economy roughly the size of a mid-range European country (e.g., Russia or Italy) was assumed. The model is quarterly.[8] Table 1 shows the boundary chart.

[8]Additionally, I have assumed for simplicity a stationary state in the sense that full-employment is associated with particular level of investment and capital rather than a particular rate of growth thereof. In reality, economies need to continue to grow to even maintain the same level of employment because increases in productivity mean that the same level of production can be reached with fewer and fewer workers.

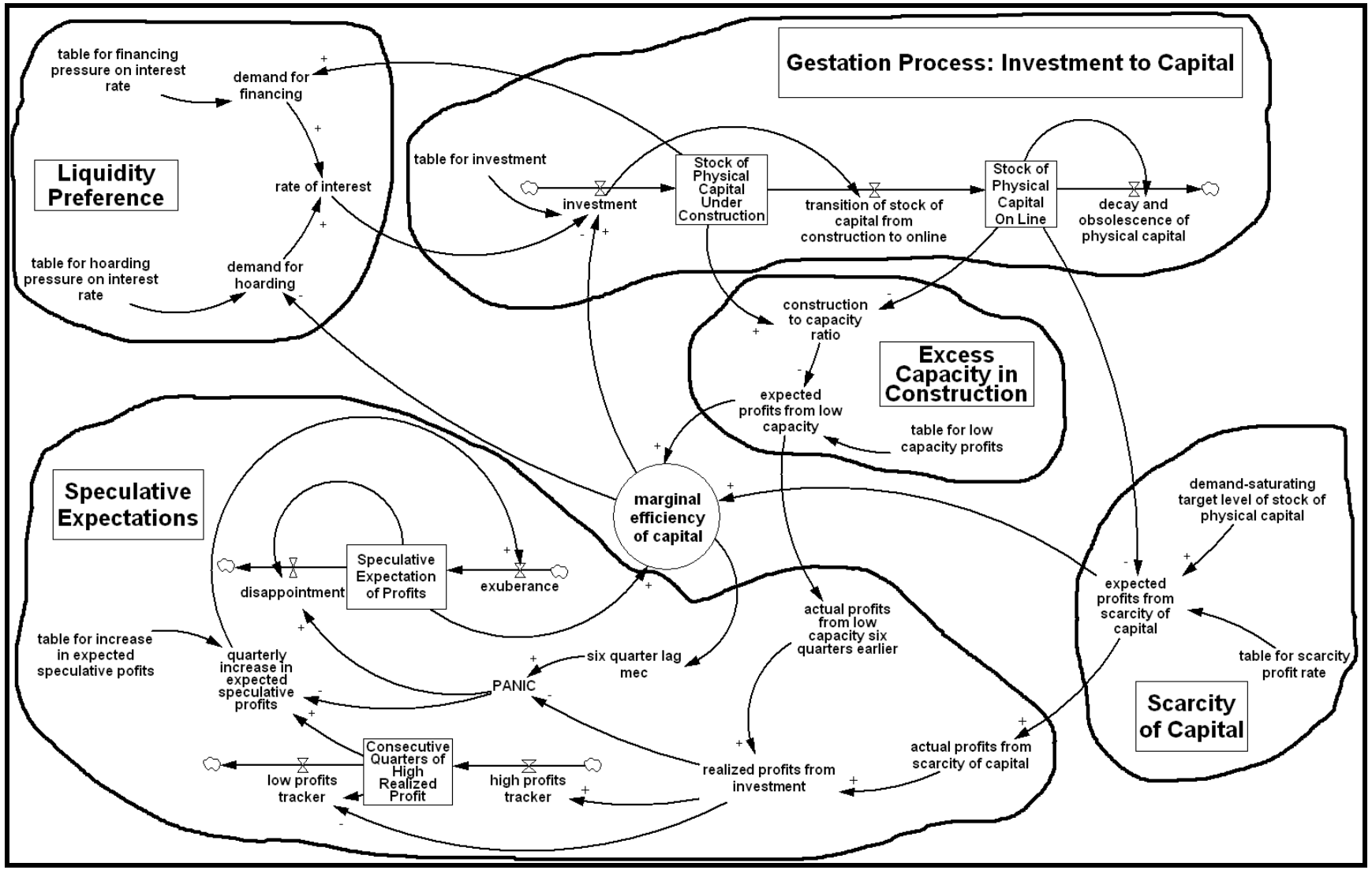

Figure 5: System dynamics model of Keynes' theory of the business cycle and crisis.

Table 1: Boundary chart for system dynamics model of Keynes' theory of the business cycle and crisis.

Endogenous	Exogenous	Excluded
• investment • stock of capital • target stock of capital • marginal efficiency of capital • rate of interest • cost of capital • profits from scarcity of capital • speculative profit expectations • realized profits	• target stock of capital • lag time for investment to come on line • agents' conception of what "high" profits are • gap between expected and actual profits necessary to induce panic • capital stock depreciation	• government • foreign sector • employment • consumption • financial market • agent debt levels • productivity growth • gdp

As explained above, investment is the key to macroeconomic growth and stability. If we are to reach full employment, then it must rise at an increasing rate, up to the point we reach GDP*.[9] Keynes argues, however, that while it may match this pattern at first, it will inevitably collapse and brings on recession and unemployment. The gestation process, shown in Figure 6, tracks the creation of physical capital from the point that it is a new investment through to that at which it comes on line and is available for use (the latter is shown as Stock of Physical Capital On Line). Based on empirical studies, it was assumed that this would require eighteen months, so that Stock of Physical Capital Under Construction is a level containing the previous six quarters of investment.[10] That level is reduced by Transition of stock of capital from construction to on line, which is a six-quarter lag of Investment. In this manner, in six quarters, investment will have passed through each of the stages shown to become part of Stock of Physical Capital On Line. Decay and obsolescence of physical capital is the rate at which capital wears out and becomes outdated. Every quarter, 5% of on line capital degrades in this fashion.[11] The primary determinant of investment is the marginal efficiency of capital. Though it is modeled as a single value, it is actually representative of one of the MEC functions from Figure 1. When compared to the prevailing rate of interest via a table (where the latter assumes an s-

[9]Neither GDP* nor employment are shown explicitly in the model. These would both be directly related to I, however, and thus show precisely the same pattern (with the caveat that unemployment tends to lead recessions and lag expansions). It would be easy enough to assume that a particular level of investment (say, around $550 billion in the current model) was associated with a socially acceptable level of unemployment (4% or so).

[10]Sterman (2000) cites Montgomery (1995) as suggesting that lags should be around 1.4 years.

[11]The magnitudes for the various capital stock and investment numbers were derived from British studies found here: http://www.statistics.gov.uk/StatBase/Product.asp?vlnk=10730.

shaped relationship with a range of values based on that witnessed in the US economy over the past twenty years), the current level of investment is determined.

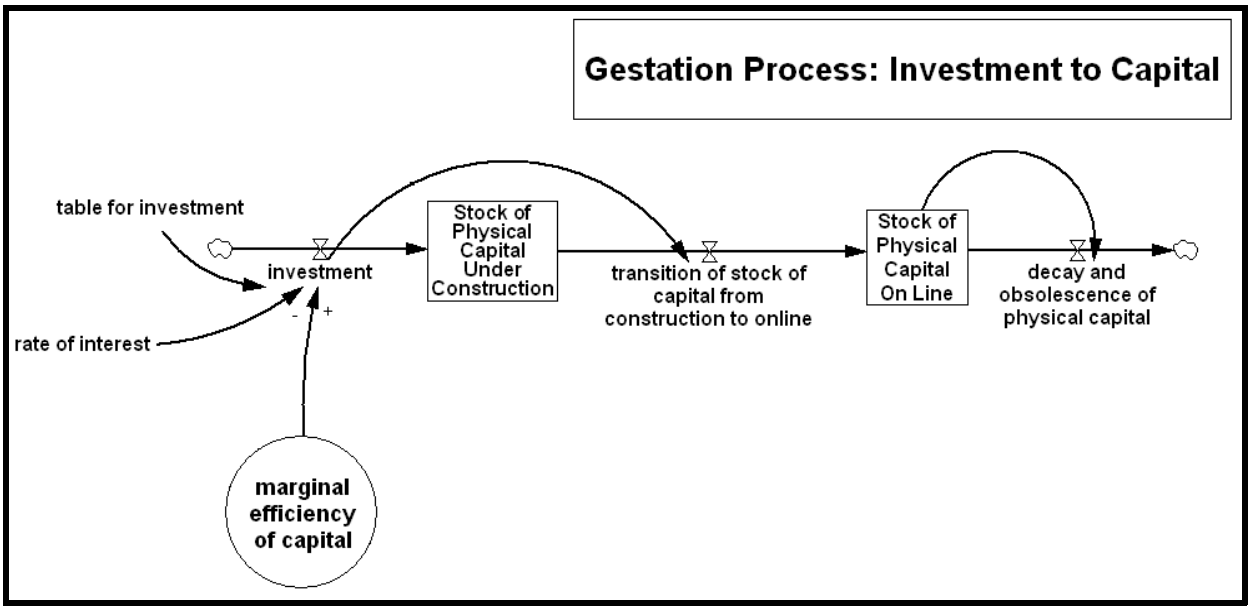

Figure 6: Gestation process, from investment to on line capital (and decay).

The mec itself is modeled as the sum of three values: expected profit based on low capacity in construction, expected profit based on scarcity of capital, and expected profit from speculation. Note that, for clarity of exposition, each was defined such that a rise in that determinant led to some positive increase in profits. What Keynes called cost of capital, for example, is modeled here as excess capacity in construction because while a rise in the former would reduce profits, a rise in the latter raises them. Figure 7 shows this relationship. The construction to capacity ratio is modeled as that between Stock of Physical Capital Under Construction and Stock of Physical Capital On Line. To generate its contribution to expected profits, construction to capacity ratio is compared to an s-shaped table that then generates values ranging from 0 (at very low excess capacity) to 3.5% (at very high excess capacity).

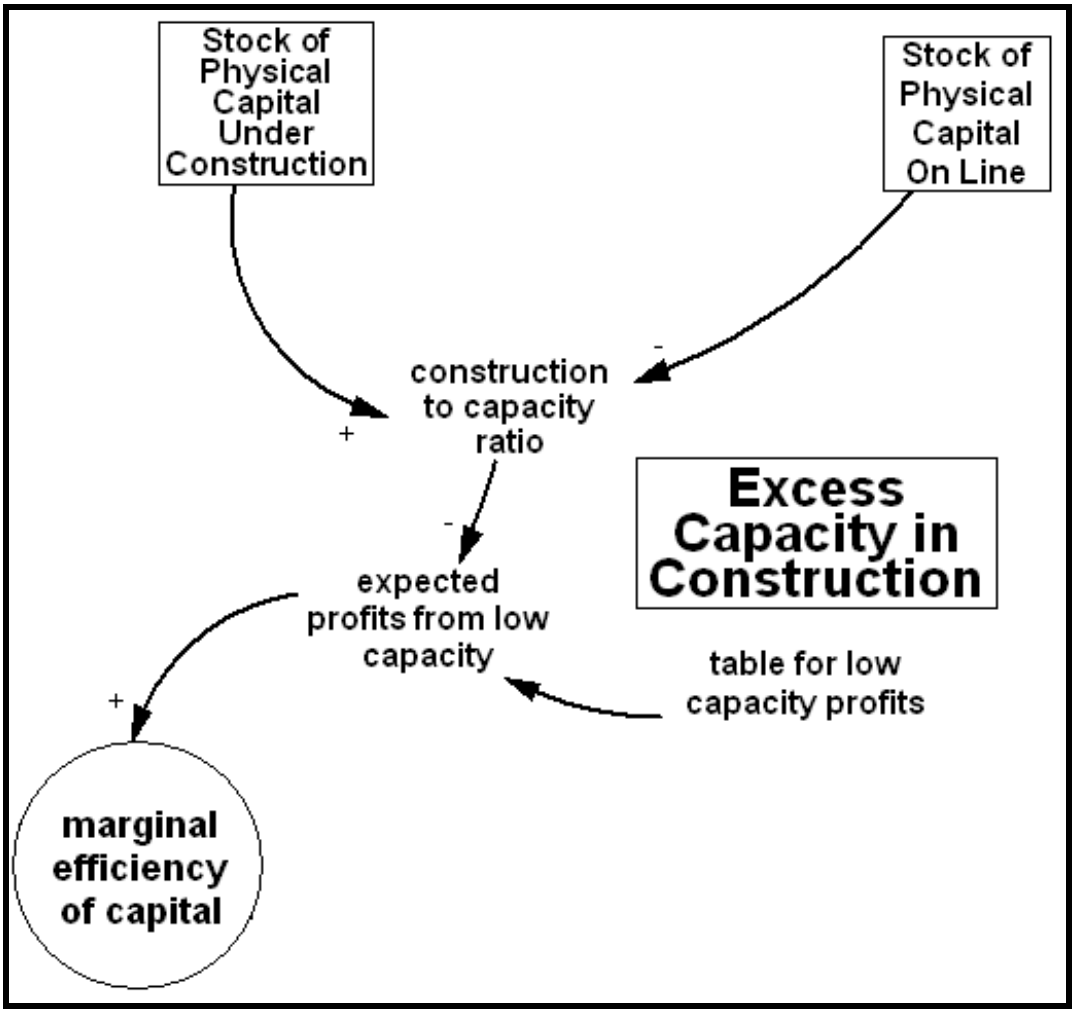

Figure 7: Keynes' cost of capital determinant of the marginal efficiency of capital.

The second component of mec is that based on capital scarcity, shown in Figure 8. Recall that Keynes believed that the more abundant capital, the lower the mec since a) the profitable investments will have been undertaken first and b) each successive addition to the stock of capital faces more and more competition. The basic measure of scarcity employed in this model is the ratio of the existing Stock of Physical Capital On line with the Demand-

Saturating Target Level of Stock of Physical Capital.[12] This number can vary from 0 (when there is no on line capital) to 1 (when on line capital is equal to the demand-saturating level), and a straight-line function was assumed (in the table) with 0 being associated with a profit rate of 15% and 1 a profit rate of 0%. This number is then added to that created by the "low capacity bonus to profits" explained above.

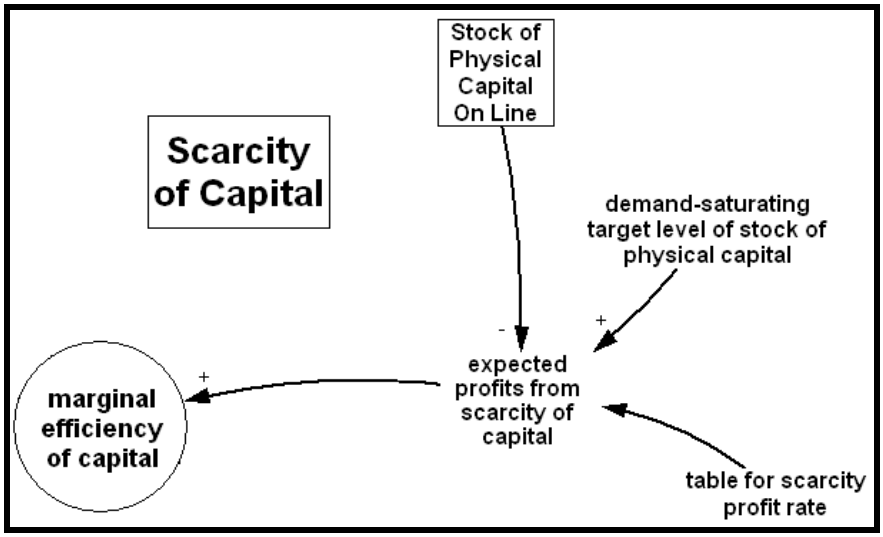

Figure 8: Profits generated by the scarcity of capital.

The last contributor to mec, profit expected by financial speculators, is the one most responsible for instability. While profits from the scarcity of capital and those from excess capacity in construction are rightly expected to decline over the course of expansion, agents, buoyed by the above-average returns, nevertheless believe that these negatives will be more than offset by the booming economy. Capturing this proved to be the most challenging part of the

[12]It need not be the "demand-saturating" level. Selecting any value would eventually generate the same patterns (assuming appropriate magnitudes for the other model parameters). Indeed, since I cannot really claim to know what the demand-saturating level is, that is all I have done. But, I thought it important to model it in this way so that Keynes' point about under versus overinvestment could be highlighted.

modeling process, the result of which is shown in Figure 9.

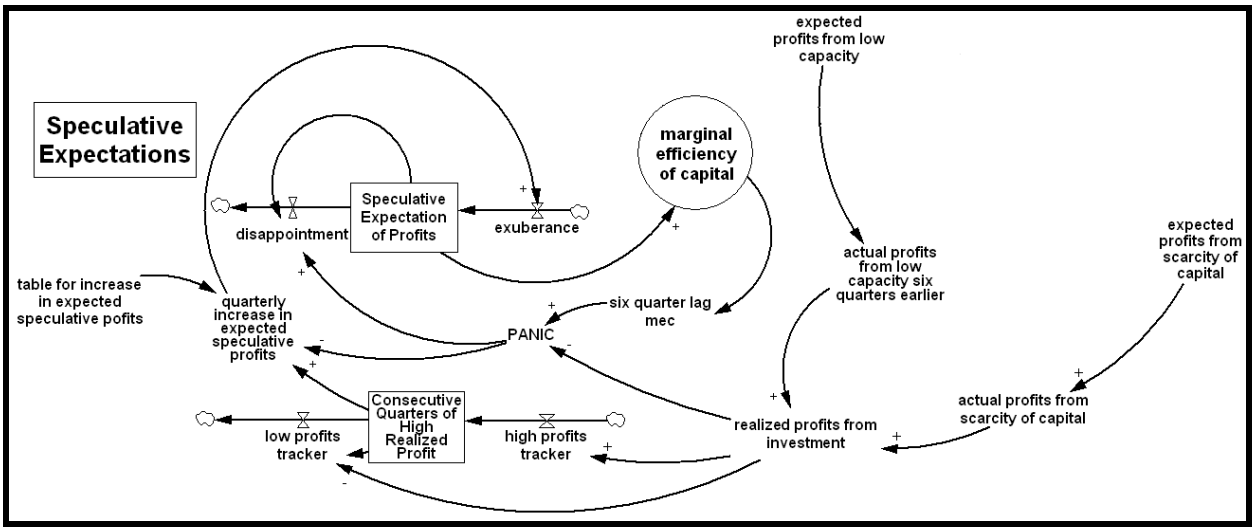

Figure 9: The impact of speculative expectations on the marginal efficiency of capital.

Three things must occur: an increase in optimism as the expansion generates above-average profits, a decline in realized returns over that same period, and panic when the gap between those two becomes too large to ignore. Showing this required the creation of a variable that showed actual rates of return on investment, which is shown as realized profits from investment. Since the actual profitability of the investment will depend on the cost of construction six quarters earlier but the scarcity of capital during the quarter when it came on line, this variable sums actual profits from low capacity six quarters earlier with current actual profits from scarcity of capital.[13] With such a variable in place, it is then a relatively simple matter to create a counter for keeping track of the number of consecutive "high" profit quarters.

[13]Note that this implies that agents' forecasts of profit based on the cost of capital and the scarcity of capital turn out to be correct. This is a simplifying assumption as, of course, they may not. But, as having them be wrong would only introduce even more instability into the relationship, this assumption biases the results against Keynes and greatly simplifies the model.

This is shown at the bottom of Figure 9. High profits tracker is an if-then statement, generating a 1 for each quarter realized profits were greater than 4% (the latter was selected as the threshold on the basis of Keynes' comments on page 321 of the *General Theory*). For every such quarter, Consecutive Quarters of High Realized Profit will increase by one. Low profits tracker is also an if-then statement, yielding a zero when profits are over 4% and the current value of Consecutive Quarters of High Realized Profit otherwise. In this way, the level resets to zero whenever there is a quarter at less than 4%.

Unless the PANIC variable is activated, Consecutive Quarters of High Realized Profit feeds into quarterly increase in expected speculative profits via an s-shaped table that generates a bonus to the profit forecast varying from 0 to 0.6%. This represents the overreaction of financial investors and through its connection to exuberance it accumulates in the level Speculative Expectation of Profits. This is then added to marginal efficiency of capital. Note that this can grow very quickly during a period of high profits since it is summing consecutive values of quarterly increase in speculative profits.

If PANIC is active, however, then regardless of the number of consecutive quarters of high profits, quarterly increase in expected speculative profits is zero. This happens whenever realized profits from investment are more than two percentage points lower than what was expected when the investment was undertaken (i.e., six quarters earlier, hence the six quarter lag mec) and investors are disappointed. PANIC also acts to reset Speculative Expectation of Profits to zero via "disappointment."

This completes the specification of the mec in the model and covers all the subsectors except that governing the interest rate (Keynes' liquidity preference theory). While Keynes

clearly states that he sees this as a secondary factor, it can nevertheless have an impact over the business cycle and should be included particularly because many economists believe it played an important role in the current crisis. But, there are always conflicting pressures at work. While during the upswing, the demand for financing may be high as new projects are undertaken, people are nevertheless confident and thus the hoarding demand for cash is low. Over the downswing, those positions reverse. To take these two distinct pressures into account, Figure 10 shows the rate of interest as the sum of the effect of the demand for financing and the demand for hoarding. The former is related by a table to the Stock of Physical Capital Under Construction, while the latter (taking the cue from Keynes) is an inverse function of the marginal efficiency of capital.

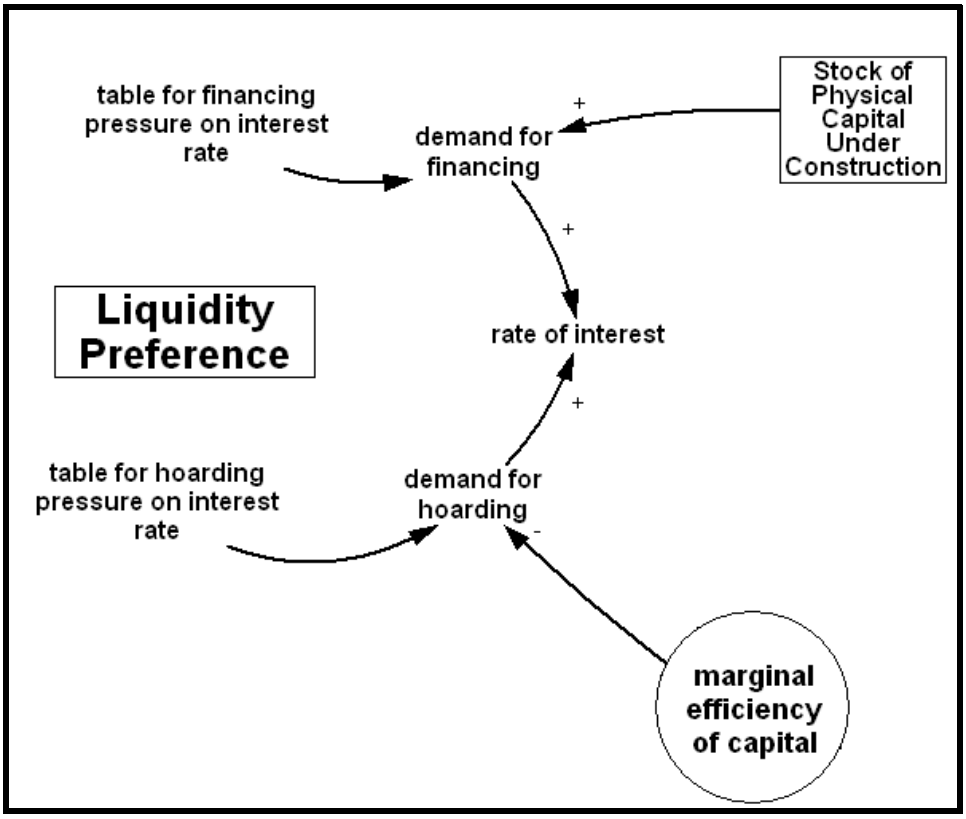

Figure 10: Determination of the rate of interest.

Validation, Sensitivity Tests, and Analysis

The system structure is very similar to the theory laid out by Keynes and it generates a business cycle of the sort described in chapter 22 of the *General Theory*. Expansions are marked by an initially gradual then steep increase in investment, which is followed by a sudden collapse. This is illustrated in Figure 11. Furthermore, the key variables fall into the expected ranges and–as predicted by Keynes–the stock of capital never reaches the saturation level.

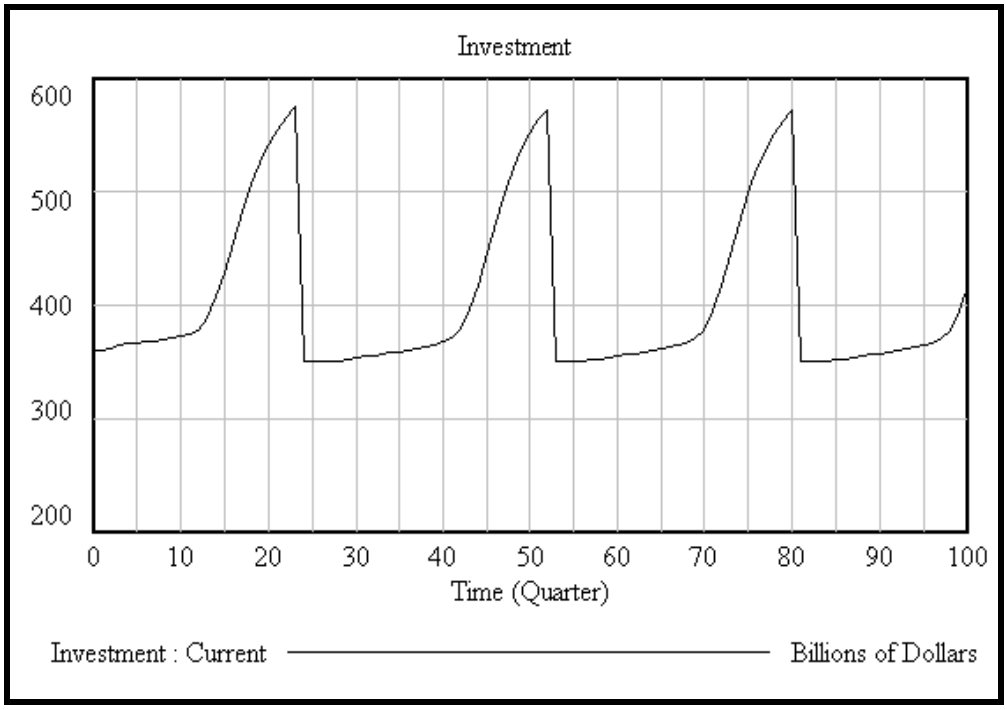

Figure 11: Pattern created by investment in system dynamics model of Keynes' theory of the business cycle.

In terms of sensitivity tests, all five of the variables listed as exogenous in Table 1 were manipulated to see if significant changes in model behavior took place. Different values for "gap between expected and actual profits necessary to induce panic," "lag time for investment to come on line," "agents' conception of what "high" profits are," and "target stock of capital" affected only the periodicity of the patterns and not their basic structure. The specification of "capital stock depreciation," however, proved to be very important. Increasing the rate at which Decay and Obsolescence of Physical Capital only changed periodicity, but lower ones led to a rapid decline in the profitability of investment and therefore a collapse. Investment found an equilibrium at which new construction was exactly offset by decay and obsolescence and, because this was inevitably at a low level of investment, the economy became trapped in a never-ending slump. This fits Keynes' concerns well and indicates that increases in the longevity of physical capital, while obviously advantageous from a technological perspective, create even more problems for the economy. Integration tests were also conducted, but no problems were revealed.

Key to understanding the structure of the model is determining the effect of each of the four sectors in Figure 5 that impact investment and, therefore, the business cycle. Keynes clearly indicates, for example, that he sees interest rates as a potentially complicating but not primary factor. To test this, separate simulations were carried out with Liquidity Preference, Excess Capacity in Construction, Profits from Scarcity of Capital, and Speculative Expectations of Profit held constant. This was accomplished by replacing that sector with a constant equal to its average contribution in the base run of the simulation.

For example, one run was made omitting the interest rate. While it remained in the

investment equation as a determinant, it was set at a constant 2.967 (its average value in the base run). This had an imperceptible effect, consistent with Keynes's argument (and contrary to what many economists argue today). The same was true when holding "low capacity bonus to profits" and "scarcity profits" constant (at 1.135 and 2.83)–periodicity, time from peak to trough, and maximums and minimums changed somewhat, but the basic patterns were the same. This was not the case with Speculative Expectations of Profit, however, as the business cycle was completely eliminated when that factor was replaced with a constant 1.019 in the equation for marginal efficiency of capital. In addition, instead of the rapid collapse of investment to an equilibrium level as was experienced in the sensitivity testing of the depreciation of the capital stock above, it rose.[14] It nevertheless left the stock of capital well sort of desired levels, but was otherwise preferable.

Policy Lessons and Conclusions

This analysis has important policy implications. First, it is unclear that interest rates can significantly affect the process. Many voices have been raised in favor of the idea that expansions should be dampened by raising interest rates. In this way, the overinvestment and overconfidence that lead to catastrophic collapse can be avoided. Keynes cautions, however, that not only are interest rates a relatively weak tool in general, but that overinvestment in a realistic sense does not occur. This is supported both by the results of the sensitivity tests and by a fresh run of the simulation conducted specifically to put this expansion-dampening theory to

[14]The simulation assuming a 2.5% rate of capital decay led to an equilibrium value of investment of around $350 billion, holding speculative expectations constant yielded almost $400billion.

the test. In it, interest rates were raised whenever the mec went above 4% by adding to the original rate (already determined by the demand for hoarding and finance) the marginal efficiency of capital minus 4%. While there is no question that this succeeded in keeping investment from fluctuating as wildly (the standard deviation falls from $71 billion in the unadjusted simulation to only $5 billion in the expansion-dampening one), it also kept it lower on average (declining from a mean of $403 billion to $369 billion) and caused the stock of physical capital, after an initial surge, to go into a mild long-run decline. This is hardly a solution to economic crises because, as Keynes suggested, such a method for "abolishing booms" keeps "us permanently in a semi-slump" (Keynes, 1964, p.322). Unemployment is higher and capacity is lower.

Instead, the problem is the financial market and the mind set that it creates. As discussed at length above, uncertainty, animal spirits, and the ability divest oneself of a financial asset within moments of acquiring it combine to create what amounts to a legitimized (by claims of rationality and market efficiency) casino. People ignorant of the fact that profits cannot continue their upward track not only bet otherwise, but they influence those undertaking physical investment. When disappointment inevitably arrives, it can do so catastrophically. The sensitivity tests above already showed the effect of removing speculative expectations from the equation: average investment falls only slightly to $396 billion (just under the $403 generated by the unadjusted model) and its standard deviation is lower even than that created by the expansion-dampening policy ($3 billion rather than $5 billion). It was as a consequence of the impact of financial markets that Keynes made the following comment:

The spectacle of modern [financial] investment markets has sometimes moved me

> towards the conclusion that to make the purchase of an investment permanent and indissoluble, like marriage, except by reason of death or other grave cause, might be a useful remedy for our contemporary evils. For this would force the investor to direct his mind to the long-term prospects and to those only. (Keynes, 1964, p.160).

Although he quickly concedes that such a measure might prove excessive and in itself serve to limit physical investment, one is left with the strong impression that he believes that something along these lines must be done. Reining in the financial sector and limiting its impact on the rest of the economy–both in 1936 and today–is the first order of business.

This still, however, leaves the problem of the overall stock of capital. On average, while under the constrained-speculation scenario it is higher than with an expansion-dampening policy ($7954 billion versus $7560 billion), it is actually lower than in the unadjusted scenario ($8115 billion). This is so because one positive side effect of the speculation was to raise investment (and therefore capital) longer than profit-maximizing entrepreneurs might have done. This points up what mainstream economics might call a market failure: that which society desires is not necessarily what free enterprise delivers. To push the stock of physical capital to the point that it is equal to the demand-saturating level, it would be necessary for firms to continue to invest up to the point that they were expecting zero profit. So long as there is a positive rate of interest, that is impossible. This is consistent with Keynes' primary policy recommendation which, contrary to popular belief (including among economists) was not deficit spending. Rather, he argued that, along with interest rates being kept as low as possible at all times and speculative influences in financial markets being reduced, the process of investment be

socialized in the sense that the government take over the responsibility of pushing the stock of capital to the saturation point. Only in this way, he believed, could we experience both sufficient investment to create full employment and a stock of physical capital that would satisfy current demand. To some extent, we already do this as the government is already involved in a considerable amount of investment (albeit without the conscious recognition of needing to close the gap described by Keynes). However, the deregulation and massive growth of the financial industry over the past several decades must be stopped and reversed if we expect the economy to recover and flourish. We have the science and technology to end almost all of the ills that have plagued humanity for thousands of years. What is lacking is a system that encourages us to use them efficiently and to their full effect.

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